# Forest Health Protection
## Pacific Southwest Region

**Date: August 10, 2012**
**File Code: 3400**

**To: Carolyn Napper, Shasta-McCloud Management Unit District Ranger**

**Subject: Trip report following site visit to Elk Flat LSR Stewardship Project to determine suitability for WBBI funding (FHP Report N12-04)**

At the requests of Christine Jordan, Natural Resource Planner (Shasta-Trinity NF) and Ed Domanski, Supervisory Forester (Shasta-Trinity NF), site visits were made to the Elk Flat LSR Restoration project area on October 28, November 1, and December 6, 2011 and July 2, 9 and 26, 2012. The objectives were to assess the current stand conditions, evaluate the project for potential funding through the Forest Health Protection (FHP) Western Bark Beetle Initiative.

**Background**

The Elk Flat LSR Restoration project involves thinning and fuels reduction treatments on approximately 2,019 acres (currently identified). The project area is located primarily within the 3,056 acre Elk Flat LSR approximately 4 miles northeast of McCloud (T 41 N, R 1 W, Sections 28-33 Mt. Diablo Meridian, average elevation 4,400 feet).

The purpose of the Elk LSR Restoration Project is to promote development of late-successional habitat and reduce the risk of existing and future habitat loss from disease, insects and wildfire on National Forest System lands within the Elk Flat Late-Successional Reserve (LSR) and adjacent matrix lands. Late seral characteristics include large overstory trees, multilayered canopy cover with some canopy gaps, patchy understory and scattered large down wood and standing snags.

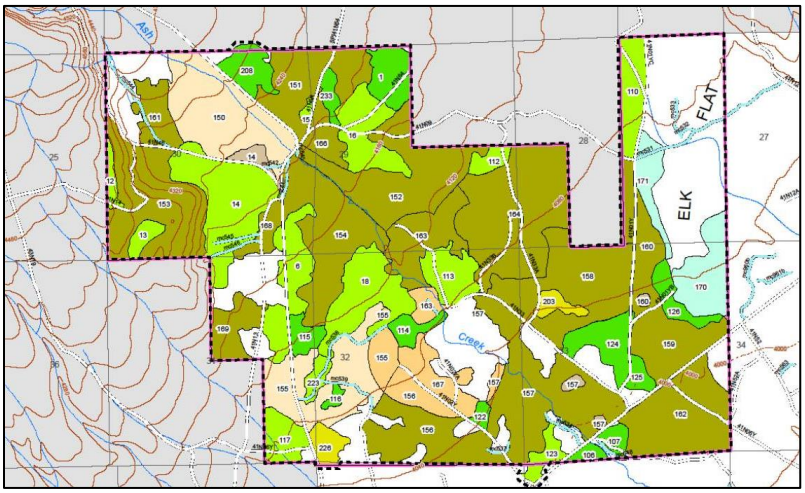


**Figure 1. Map of project area with stands color coded according to proposed treatments.**

Although ponderosa pine mortality has been occurring regularly across the entire McCloud Flats due to a complex of

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black stain root disease and western pine beetle, there has been a marked increase in pine mortality over the past three years within the project area. In light of recent and ongoing pine mortality, objectives stress protecting stands from further bark beetle-caused mortality, increasing tree vigor and resilience to insects and diseases, addressing heavy fuels loads and regeneration.

In order to mitigate black stain root disease and bark beetle-caused mortality in the project area, reduce wildfire risk, develop and maintain late successional stand characteristics and improve tree resilience/vigor, the Proposed Action includes thinning natural stands and plantations in all size classes and treatment of all surface and ladder fuels through piling and burning as well as understory/broadcast burning.

**Observations**

Stands within the project area are predominantly ponderosa pine (*Pinus ponderosa*) and white fir (*Abies concolor*). White fir is especially prolific in the understory (trees 12" DBH and less). In natural stands, ponderosa pine is primarily a component of large overstory trees (30" DBH and greater) found in combination with white fir, incense cedar (*Calocedrus decurrrens*), with few scattered Douglas-fir (*Pseudotsuga menziesii*) and sugar pine (*Pinus lambertiana*). Hardwoods, such as aspen (*Populus tremuloides*) and black oak (*Quercus kelloggii*) are rare within the project area.

Much of the area was originally logged around the turn of the century. Selective overstory removal/sanitation cutting has occurred over the last 30 - 80 years as evidenced by scattered stumps, predominantly pine. Plantations range from 10 to over 40 years old. Stands range from being uniformly dense, to being clumpy with small scattered openings. Current stand conditions reveal increased densification of a shade tolerant understory and mid-story, composed primarily of white fir and incense cedar.

The measurement of stand density index (SDI) is used to relate stand density to the biological carrying capacity of a stand. Barring disturbance, stand density increases over time as trees grow increasingly larger. For most species, as stands reach and exceed densities of 60% of a maximum SDI, density related tree mortality becomes increasingly evident. An SDI of 365 is considered limiting for ponderosa pine due to increased risk of bark beetle-caused mortality. As ponderosa pine-dominated stands reach and exceed an SDI of 230 (roughly 60% of the SDI of 365) bark beetle-caused mortality is increasingly likely. Most of the proposed units are at or exceed 60% max SDI.

Pockets of recent and ongoing mortality in ponderosa pine are occurring in numerous stands throughout the project area as a result of a complex of black stain root disease (*Leptographium wageneri*) and western pine beetle (*Dendroctonus brevicomis*). Mortality pockets range from several (10 – 25) trees to several acres in size. The current pine mortality occurring from western pine beetle where black stain root disease is not found bears out the limiting stand density relationship described above.

Stand exams of natural stands (non-plantations) in the project area measured densities above an SDI of 230, and two thirds exceeded an SDI of 365. Additionally, older (over 40 years old) pine plantations are also near or above an SDI of 365. These acres are also heavily infected with black stain root disease, which causes reduced growth, chlorosis, dark staining of the tracheids extending from the roots to the lower bole, and ultimately tree death. When tree death does not occur, the disease sufficiently weakens infected trees to be easily overcome by bark beetle attacks.

Heterobasidion root disease in both white fir (*Heterobasidion occidentale*) and ponderosa pine (*H. irregulare*) is fairly widespread in a few stands and is likely present to a more limited extent throughout much of the project area. Scattered light levels of mistletoe infection are present in both white fir and pine, but are not above endemic levels.

**Figure 2. Dense pine dominated stand (Unit 176) with mortality caused by black stain root disease and western pine beetle.**

**Figure 3. Overly dense stand (Unit 206) of ponderosa pine with mortality caused by black stain root disease and western pine beetle.**

The first visit I made to the Elk LSR was in 2010 when we looked at units 160 and 161 with Craig Sewell, Forester (Shasta-Trinity NF). The average basal area at that time was 246 sq.ft./acre and the stand density index (SDI) was approximately 361 with

approximately 145 trees per acre. The stand had been selectively logged 102-112 years ago. The stand was naturally regenerated after the initial harvest. Heterobasidion root disease was found infecting true fir in stand 160. The presence of this disease was confirmed by the presence of fruiting bodies found in some widely scattered white fir stumps and scattered groups of blowdown exhibiting laminate decay in the roots. The presence of slow-growing tops on many understory and intermediate white fir suggested that Heterobasidion was fairly widespread within the stand. Fir engraver beetles (*Scolytus ventrallis*) were present in dead and dying white fir. Bark beetles were noted in ponderosa pine, but no Heterobasidion was found in pine stumps and black stain root disease was also not noted at the time. Unit 161 had a basal area of 284 sq.ft./ac. and an SDI of 452. Logging history is thought to be from 1896 to 1907, the same time period as stand 160. Both units were overstocked and showing stress.

On subsequent visits made on October 28 and November 1, 2011 and July 2 and 9, 2012, I found evidence of black stain root disease and western pine beetle-caused mortality in Stands 162, 176, 157, 158, 159, 206 and 204. Stands remain very dense and stressed. Even in areas where thinning had been done, blackstain root disease remained active in the residuals causing mortality either directly or by keeping the stress level very high leading to further bark beetle-caused mortality.

## Discussion

In 2006, Entomologist Dave Schultz wrote: "Black stain root disease has been present in the ponderosa pine on McCloud Flats since at least the 1960s. Black stain root disease has not always been recognized, and a lot of time and effort has been spent chasing beetles. Due to repeated entries to do salvage and sanitation, a lot of stumps were created on the Flats. Stumps are the main entry court for infection of pines by spores of *Heterobasidon annosum*. Infection can be prevented by treating stumps with a registered borate pesticide. Because the use of borate stump treatments did not become a routine treatment until the latest revision of the Forest Plan, there are numerous annosus root disease pockets on the Flats. Both black stain and annosus root disease may be present in the same stand."

He also noted that, on quality growing sites, pines may be almost dead before they even look sick. Excavated roots on off-color ponderosa pines in the area had shown the tree having grown over and buried black stain after the tree responded to previous thinning. The restriction of black stain to recent rings results from fungal colonization of the tracheids of active xylem. Because blackstain root disease is a vascular wilt rather than a root rot, it is suggested that if the host were to be removed the disease would die out quickly within the stand. However, if overstory pines need to be left in a stand known to harbor black stain root disease, the best way to avoid future root disease problems would be to leave full crowned trees at about 70 foot spacing. The remaining trees may still harbor the disease, and may eventually succumb, but opening the stand to direct sunlight would warm and dry the soil conditions thereby greatly reducing the progression of the disease.

The black stain pathogen may remain active in stumps for only a short time following harvest, often less than three years, as it dies rapidly after the death of host tissues. Severity and rates of spread of the disease are positively related to host density similar to bark beetle-caused mortality. Trees in decline due to black stain root disease are predisposed to infestation by both root- and bole-inhabiting species of bark beetles. Presence of persistent black stain root disease infection centers can thus maintain local populations of bark beetles, initiating bark beetle mortality centers. Maintaining trees in vigorous condition with adequate spacing has been suggested as the most useful long-term strategy for minimizing losses to both black stain root disease and western pine beetle.

The Elk Flat LSR is exhibiting conditions that are typical for drier mixed conifer and eastside pine-dominated forests. All stands in the project share common characteristics such as high stand densities, high accumulations of fuels, dense understories, and mortality of larger trees due to bark beetles. In general, thinning pine stands down to at least 80 sq.ft./acre can reduce their susceptibility to bark beetle attacks. This type of treatment is more effective when residual trees are smaller in diameter and includes the removal of individual trees that are currently infested with bark beetles. However, with the levels of black stain root disease known to be infecting pine on the McCloud Flats, a heavier thin would be recommended, up to complete removal of host for up to 2 years, to allow sunlight to reach the soil and slow the progression of the disease in areas with identified black stain root disease infection centers.

When carrying out thinning treatments in pine stands, it is recommended that a registered borate compound be applied to all freshly cut stumps >14” dbh. This will reduce the chance of successful colonization of stumps by spores of Heterobasidion, the causal agent of Heterobasidion root disease.

Thinning projects in this area, including natural stands and older plantations, would meet the minimum requirements for western bark beetle funding and are supported by the FHP staff through this evaluation (except for the potential salvage operation at Unit 206 as FHP money cannot be used to remove dead trees). The Elk LSR Stewardship Project fits well with Western Bark Beetle Initiative guidelines for opportunity to reduce risk of bark beetle-caused mortality.

If you have any questions regarding this report and/or need additional information, please contact Cynthia Snyder at 530-226-2437 or Pete Angwin at 530-226-2436.

/s/ Cynthia Snyder

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## Insect and Disease Information

### Western Pine Beetle (*Dendroctonus brevicomis*)

**Hosts:** Ponderosa pine and Coulter pine

**Distribution in California:** Throughout the range of suitable host trees.

**Identification:** Smallest of the western Dendroctonus species, this black cylindrical beetle is about the size of a grain of rice (4 mm long). Egg galleries are winding and packed with frass. Larval galleries lead away from the main gallery for short distances before turning into the outerbark. Small, reddish pitch tubes (sometimes fairly obscure) are signs of successful attack. Attacked trees often exhibit woodpecker feeding with only portions of the outer bark removed. Sapwood of infested trees usually shows evidence of the characteristic bluestain associated with fungi introduced by attacking beetles.

**Effects:** Successful attacks result in death of the host tree. Groups of trees are sometimes killed, especially when growing under crowded conditions. Since larger trees are generally preferred, the western pine beetle can dramatically alter the character of a forest that comes under attack.

**Ecological Role:** The western pine beetle serves as a key mortality agent for ponderosa pines weakened by the effects of old age, drought, smog, diseases, or competition with other trees.

Stand structure can be altered and gaps can be created in the stand as the bark beetles kill larger trees, either singly or in groups. In those instances where ponderosa pine occurs in mixed stands with firs, the western pine beetle can accelerate the successional process by selectively removing the early seral species from the stand. Trees infested by the western pine beetle provide temporary food sources for woodpeckers and other insectivores. Infestation by western pine beetle sets the stage for other agents, such as wood borers and decay fungi that are involved in the recycling of nutrients back into the soil.

**Life History:** In the northern part of its range and at higher elevations, the western pine beetle completes two generations in one year, with adult beetles flying in early to mid-June and mid to late August. In the southern part of its range and at lower elevations, the beetles produce three and sometimes four generations per year. Attacks may be as early as March and as late as November. Female beetles locate a suitable host and initiate attacks by burrowing through the bark. They release a pheromone that attracts other beetles and leads to mass attacks of the host tree and sometimes several trees in a group. Each female lays about 60 eggs in individual niches cut in the sides of the egg gallery. These eggs hatch in two weeks and young larvae feed initially in the phloem, later moving into the outer bark where most of their development takes place. After four larval stages, the insects turn into pupae and then adults.
Conducive Habitats: The western pine beetle breeds most commonly in trees of reduced vigor. While older, larger trees are generally preferred, younger trees can also be infested, especially when they occur in dense stands, are infected by pathogens, or are damaged by

fire. During periods of drought, the western pine beetle will be particularly prominent and can overcome apparently healthy trees.

**Similar Insects:** Other bark beetles attacking ponderosa pine may be distinguished from western pine beetle by their egg gallery characteristics and adult appearance. Egg galleries of the mountain pine beetle are straight and vertical, and those of the engraver beetles possess a nuptial chamber with one to several tunnels radiating out from it. Engraver beetle egg galleries are free of frass. Ips adults display a pronounced concavity at the rear end of the elytra that possesses three to six spines on either side. The elytral declivity on Dendroctonus adults is rounded and does not possess any spines.
Management Strategies: The detrimental effects of western pine beetle can best be minimized by providing vigorous growing conditions for host trees. Stand densities below the "Upper Management Zone" (Cochran 1992; Cochran et al 1994) will provide sufficient growing space for trees and will minimize potential habitat for the western pine beetle. Dendroctonus beetle group-kills cause a limiting Stand Density Index of 365 that differs little between stands on good and poor sites in California (Oliver 1995). In the past, "high-risk" trees (those most likely to be infested by the western pine beetle) were identified by various hazard rating systems (Keen 1936; Salman and Bongberg 1942; Smith et al. 1981) and removed. Short-term treatments are also available to protect individual, high value trees such as spraying insecticides on tree boles to prevent bark beetle attacks. Other short-term treatment options for individual trees are currently being evaluated such as the use of anti-aggregation pheromones and non-host angiosperm volatiles. Tree injection systems are being explored to treat trees with systemic insecticides.

**Black Stain Root Disease (*Leptographium* (Verticicladiella) *wageneri*)**

**Hosts:** Ponderosa and Jeffrey pine, pinyon pine, and Douglas-fir. Lodgepole pine, western hemlock, mountain hemlock, sugar pine and knobcone pine are also susceptible, but damage is rare.

**Distribution in California:** Southern Cascades and northern Sierra Nevada (ponderosa and Jeffrey pines); southern California (singleleaf pinyon pine); throughout the range of Douglas-fir.

**Characteristics:** There are three distinct taxonomic varieties (subspecies) of the blackstain root disease pathogen. Each variety has a unique set of hosts, and all are found in California. Leptographium *wageneri* var. *wageneri* is pathogenic to pinyon pine; *L. wageneri* var. *pseudotsugae* causes black stain root disease in Douglas-fir; and *L. wageneri* var. *ponderosum* attacks ponderosa, Jeffrey and lodgepole pine, and occasionally sugar pine and hemlock. Blackstain root disease is a vascular wilt disease. It kills trees by blocking their water conducting vessels, and can cause substantial mortality. It does not cause decay of root or stem tissue.

Colonization of the root system causes a visible decline in the tree crown. Terminal growth is reduced, needles become shorter and chlorotic, the number of needles produced and retained is reduced ("lion's tail" appearance of branches), and finally the host dies. Disease centers appear as small (usually less than 0.04 ha or 0.1-ac) groups of dead and symptomatic trees. Infection centers can sometimes be much larger, especially in ponderosa pine stands. Unless also affected by root rot fungi, trees killed by black stain root disease usually remain standing. Typical infection centers have trees in various stages of decline near the perimeter and dead trees in the interior where infection originated. Trees with black stain root disease are frequently predisposed to bark beetle infestation.

**Symptoms and Signs:** Black stain root disease is relatively easy to identify in the field. It produces a distinctive dark brown to black sapwood stain in the roots and root crown that sometimes streaks upward into the lower bole. Cross sections of the wood reveal the stain to be in arcs that follow the annual rings. This stain differs from blue stain, which is more bluish, wedge-shaped in cross section, follows the rays, and is associated with beetle galleries throughout the tree. In black stain-infected overstocked pole sized ponderosa or Jeffrey pine stands or understories, a common symptom is numerous haphazardly fallen stems laying in a 'jack-strawed' manner.

**Disease Cycle:** Infection centers may be initiated by root-feeding bark beetles and weevils that carry fungal spores on their bodies. These insects are attracted to wounds, the roots of fresh stumps, and weakened, low-vigor trees, which may account for the common association of the disease with disturbances. Infection of pines appears to be favored by wet, cool environments.

Local tree-to-tree spread is via infection of small rootlets, following either root contact or short distance growth of the fungus through soil. Disease centers can enlarge at a rate of

four to twelve feet per year. Although the fungus can remain for long periods in live host tissue, it is relatively nonpersistent and is difficult to isolate from previously infected wood much more than a year after the tree dies.

**Damage and Importance:** Black stain root disease usually is found in areas where there has been significant site disturbance or substantial amounts of tree injury, especially in stands after precommercial thinning, along roads, skid trails and landings, on sites with drought-stressed, waterlogged, or compacted soils, or where rotary blade brush cutters have been used to clear roadsides. Certain characteristics are related to black stain root disease in ponderosa pine in the central Sierra. Stands are usually densely stocked and consist of either pure or predominantly ponderosa pine. The largest and most rapidly expanding disease centers are often in cool, low lying sites with high soil moisture levels in the spring.

In recent years, black stain root disease has been detected in many new areas, often causing locally severe damage. Incidence appears to be steadily increasing. While the disease is common in cool, wet, overstocked and disturbed sites, bark beetle-caused mortality of trees that are weakened by *L. wageneri* can likewise be significant during periods of drought and other stress.

**Ecological Roles:** *Leptographium wageneri* creates stand openings, enhances diversity, provides wildlife habitat, and alters forest structure, composition, and succession. Black stain root disease's impacts should be considered from the perspective of how they will influence the ability to attain the desired stocking necessary for meeting management objectives. As with other root diseases, high levels of inoculum in relatively pure stands of susceptible species may preclude achieving adequate stocking in the future.

**Management Strategies:** At the present time, there is no effective cure for trees that are already infected, and genetically resistant host genotypes have not been identified. Indications from the few long-term field studies that have been conducted suggest that disease impacts may be minimized by maintaining trees in a vigorous condition with adequate spacing while avoiding disturbance and injury, especially during times of peak beetle activity. Partial cutting to attain these objectives can increase or decrease black stain root disease incidence in a stand, depending on several factors, including the amount of soil disturbance that occurs; the time of year that the partial cutting is performed; the amount of host-to-host root contact that remains; and the amount of damage inflicted on residual trees. Several management actions have been suggested to reduce the establishment of new infections and minimize the effects of the disease where it is already present:

• When establishing new stands in or near areas where black stain has been a management concern, a mix of species should be planted to provide future options for species manipulation.

• When thinning, thin aggressively during each entry, leaving an understocked stand. This will reduce the frequency of harvest entries and associated soil disturbance. Reduced stocking may contribute to disease resilience in a stand because uncrowded trees are

more vigorous and less attractive to insect vectors of *L. wageneri* and other bark beetles. Open stands will also have warmer soils that inhibit *L. wageneri* and fewer root contacts between susceptible trees.

• Thin stands as early in the rotation as possible.

• During thinning, favor tree species that are resistant or immune to the locally important variant of *L. wageneri* and remove diseased or weakened trees.

• Whenever possible, leave trees that are not hosts for black stain root disease.

• When host tree species have been removed from an infection center, wait at least two years before replacing with host species.

• Harvest in a manner that minimizes soil disturbance and injury to the roots and boles of residual trees.

• If possible, thin when insect vectors are least active, generally from late June to early September, allowing time for roots to dry out by fall. In areas where summer months are dry and droughty, the thinning period may be extended into late September. Late fall thins are not recommended because stumps may still attract insect vectors the following spring.

• Reintroduce frequent low intensity ground fires into the landscape. This will prevent ingrowth of brush or conifers which can stress host trees and create host-to-host root contacts. Monitor post-harvest black stain root disease activity to evaluate the effectiveness of various levels of thinning.

## Heterobasidion Root Disease (formerly Annosus Root Disease)

Heterobasidion spp. is a fungus that attacks a wide variety of woody plants. All western conifer species are susceptible. Madrone (*Arbutus menziesii*), and a few brush species (*Arctostaphylos* spp. and *Artemisia tridentata*) are occasional hosts. Other hardwood species are apparently not infected. The disease has been reported on all National Forests in California, with incidence particularly high on true fir in northern California, in the eastside pine type forests, and in southern California recreation areas.

Heterobasidion root disease is one of the most important conifer diseases in Region 5. Current estimates are that the disease infests about 2 million acres of commercial forestland in California, resulting in an annual volume loss of 19 million cubic feet. Other potential impacts of the disease include: increased susceptibility of infected trees to attack by bark beetles, mortality of infected trees presently on the site, the loss of the site for future production, and depletion of vegetative cover and increased probability of tree failure and hazard in recreation areas.

During periods favorable to the fungus, fruiting bodies (conks) form in decayed stumps, under the bark of dead trees, or under the duff at the root collar. New infection centers are initiated when airborne spores produced by the conks land and grow on freshly cut stump surfaces. Infection in true fir may also occur through fire and mechanical wounds, or occasionally, through roots of stumps in the absence of surface colonization. From the infected stump surface, the fungus grows down into the roots and then spreads via root-to-root contact to adjacent live trees, resulting in the formation of large disease centers. These infection centers may continue to enlarge until they reach barriers, such as openings in the stand or groups of resistant plants. In pines, the fungus grows through root cambial tissue to the root crown where it girdles and kills the tree. In true fir and other non-resinous species, the fungus sometimes kills trees, but more frequently is confined to the heartwood and inner sapwood of the larger roots. It then eventually extends into the heartwood of the lower trunk and causes chronic decay and growth loss.

Heterobasidion root disease in western North America is caused by two species:

*Heterobasidion occidentale* (also called the 'S' type) and *H. irregulare* (also called the 'P' type). These two species of Heterobasidion have major differences in host specificity. *H. irregulare* („P‟ type) is pathogenic on ponderosa pine, Jeffrey pine, sugar pine, Coulter pine, incense cedar, western juniper, pinyon, and manzanita. *H. occidentale* („S‟ type) is pathogenic on true fir, spruce and giant sequoia. This host specificity is not apparent in isolates from stumps; with *H. occidentale* being recovered from both pine and true fir stumps. These data suggest that infection of host trees is specific, but saprophytic colonization of stumps is not. The fungus may survive in infected roots or stumps for many years. Young conifers established near these stumps often die shortly after their roots contact infected roots in the soil.